

# German wide cross sectional survey on health impacts of electromagnetic fields in the view of general practitioners

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## Abstract

**Objectives** The proportion of general practitioners (GPs) in Germany who assume health impacts of electromagnetic fields (EMF) is assessed. Moreover, factors associated with this risk perception are examined.

**Methods** A 7% random sample was drawn from online lists of all the GPs working in Germany. 1,867 doctors received a long version of a self-administered postal questionnaire about EMF and health (response rate 23.3%), 928 doctors received a short version (response rate 49.1%).

**Results** 37.3% of responders to the short and 57.5% of responders to the long questionnaire agreed “that there are persons whose health complaints are caused by EMF when legal limit values are met”. A late responder analysis for the survey with the short questionnaire led to a still lower estimate of 29% for GPs believing in health-relevant effects of EMF.

**Conclusion** About a third of German GPs associate EMF with health complaints and thus deviate considerably from current scientific knowledge. To avoid a strong selection bias in the surveys of the perception of EMF risks, use of short questionnaires and late responder analysis are recommended.

**Keywords** Risk perception · Electromagnetic fields · General practitioners · Selection bias · Late responder analysis

## Introduction

Concern about adverse health effects of electromagnetic fields (EMF) is widespread in Western populations. Hence, the prevalence of persons expressing concern about EMF was reported to be 27% in Germany for 2006 (INFAS 2006), and the proportion of people concerned about at least one EMF source was estimated at 52.9% in Switzerland (Schreier et al. 2006). Moreover, a considerable proportion of Western populations attributes health symptoms to EMF (Hillert et al. 2002; Levallois et al. 2002; Blettner et al. 2009; Berg-Beckhoff et al. 2009). One would expect that a good deal of people attributing their health problems to EMF go to see a general practitioner (GP). We assume that GPs, in particular GPs offering complementary medicine, play a major role when it comes to strengthening or weakening patients' associations of health symptoms with EMF.

The perception of EMF risks in view of GPs was examined in Switzerland and Austria (Huss and Rösli 2006; Leitgeb et al. 2005). In the Swiss study 61.4% of the GPs believed that “there are people with health complaints caused by electromagnetic fields” and only 27.2% disagreed. In the Austrian study, GPs were asked whether they thought that electromagnetic pollution could cause illness: 95% of the physicians agreed at least to some degree, and 33% were even convinced that electromagnetic pollution could cause illness.

The aims of the present study were (1) to assess the proportion of GPs associating health complaints with EMF

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in Germany, (2) to examine the role of selection bias caused by low response rates in such surveys, and (3) to examine some factors which might predict how GPs perceive EMF risks.

## Methods

### Samples

Samples were drawn from lists of GPs published online by the 17 Regional Associations of Statutory Health Insurance Physicians (Regional ASHIPs). Most German GPs agree to this publication of their names and surgeries: according to the data of the National Association of Statutory Health Insurance Physicians, 41,438 GPs were registered on the 31 December 2007. In the online lists mentioned before about 40,000 GPs were included between December 2007 and February 2008. 7% samples were drawn from each of the 17 lists. In some cases, sampling was done by Regional ASHIPs, otherwise it was carried out using the online lists and a random number generator implemented in SPSS 14.0. In total, 2,795 addresses from GPs were randomly drawn from the 17 regional ASHIPs. The members were distributed arbitrarily into two groups: two-thirds ( $n = 1,867$ ) received a long self-administered postal questionnaire (see below) and one-third ( $n = 928$ ) received a short questionnaire. The long questionnaire covered four pages, the short questionnaire only one page. Physicians who had received the long questionnaire and who had not responded were sent the questionnaire once again 4 weeks later. The short questionnaire was sent to non-responders once again after 4 weeks and a third time after 8 weeks.

### Questionnaires

A short and a long questionnaires were used. Beside other questions, the long questionnaire contained two items concerning the perception of EMF risks. The first item had already been used in a Swiss study (Huss and Rösli 2006): “Do you believe that there are persons whose health complaints are caused by electromagnetic fields?” Perception of risk was asked for in a different way with a second item: “Are there persons whose health complaints are caused by EMF when legal limit values are met?” The two questions were distributed at different places inside the questionnaire. The first was placed at the beginning after the questions on personal data and the second was asked in the middle. Beside the two items mentioned above, the long questionnaire contained questions about some personal data, about the experiences of the GPs with EMF as a topic in their surgeries and about participants’ knowledge about relations between EMF and health, about

participants’ information seeking concerning this topic, about participants’ confidence in some organizations like WHO and the Federal Office for Radiation Protection. Moreover, participants were asked whether they thought that their own health was compromised by EMF. Finally, participants were asked to what degree they were personally concerned about 13 different health risks (like traffic noise, smoking, air pollution, and various EMF sources). The short questionnaire contained only a few, but most important items of the long questionnaire about demographic characteristics, concern about EMF, general experience of the GPs with EMF consultations, and the participants’ confidence about organisations like the WHO.

### Statistical analysis

The proportion of GPs who associate EMF with health complaints was determined once in the study group with the short and twice in the study group with the long questionnaire—in the latter two different items concerning perception of EMF risks were included (see above). In addition, a late responder analysis was done for the item “Are there persons whose health complaints are caused by EMF when legal limit values are met?” (short questionnaire). The first third of the participants who had filled in the short questionnaire was considered as early responders. The second third of the participants was categorized as intermediate responders, and the last third of the participants as late responders. However, the formation of precise tertiles was not possible because many questionnaires returned on the same day. To include non-responders into the estimate, the trend found in early, intermediate and late responders was extrapolated to non-responders in a linear regression analysis (Armstrong and Overton 1977). In this analysis, the proportions of agreement to the item in the three response waves were plotted versus the cumulative response rates at the midpoints of the corresponding response waves (early, intermediate, late responders). If there were  $n_1$  early,  $n_2$  intermediate,  $n_3$  late and  $n_4$  non-responders and  $n$  subjects in the whole sample, the cumulative response rates at the midpoints of the response waves were  $(0.5n_1)/n$  for the early responders,  $(n_1 + 0.5n_2)/n$  for the intermediate responders,  $(n_1 + n_2 + 0.5n_3)/n$  for the late responders, and  $(n_1 + n_2 + n_3 + 0.5n_4)/n$  for the non-responders. From the estimated regression equation, a proportion of agreement could be assessed for the cumulative response rate at the midpoint of the non-responder group.

To determine predictors of perception of EMF risks a multiple logistic regression analysis was carried out with the data obtained with the long questionnaire. The dependent variable was derived from the answers to the item “Do you believe that there are persons whose health complaints

are caused by EMF?" (The answers "no" and "don't know" were combined to build the reference category). The independent variables were the following: age (<45/45–54/55–64/>64), gender, site of surgery (rural/urban/suburban), region (Northern/Western/Eastern/Southern Germany), confidence in the WHO (high/low), subjective level of knowledge about EMF and health (good/bad), additional education in alternative medicine (yes/no) and tertiles of general concern about health risks. A value for general concern was calculated by adding up the ratings of the single health risks (with the exception of EMF risks) and by building three categories (high/intermediate/low) which accorded with the tertiles of the sum of the single ratings. Subjects with missing values for at least one independent variable were not included in the analysis; so the logistic regression model was fitted for the data of 406 out of 435 subjects. Likelihood ratio tests were carried out to test for statistical significance of each independent variable.

Statistical analyses were done with SPSS 14.0.

**Results**

The response rate was 49.1% for the short questionnaire (456 questionnaires were returned) and 23.3% for the long questionnaire (435 questionnaires were returned). For both surveys, response rates in the different parts of Germany did not differ widely (cf. Table 1). Participants in the two surveys hardly differed in their demographic features, in the proportion of medical specialists, and in the proportion of physicians with an additional education in alternative medicine (cf. Table 1).

In the short questionnaire, 37.3% agreed to the item "Are there persons whose health complaints are caused by EMF when legal limit values are met?", whereas 57.5% did so in the long questionnaire. A late responder analysis was done with the data of the short questionnaire for the same item. Among 177 early responders, 41.8% assumed an association between EMF and health complaints even when legal limit values are met. This proportion was lower among 137 intermediate and 142 late responders (37.2 and 31.7%, respectively) (cf. Table 2). In the late responder analysis we assumed that the trend observed between the response rates and the proportions of GPs believing in EMF health effects could be extrapolated to non-responders. In a regression analysis, we assessed a figure of 21.5% of agreement to the item for the cumulative response rate at the midpoint of the non-responder group. From this, an agreement of 29.3% to the item was calculated for the whole sample.

In the long questionnaire, 54.3% of the participants confirmed that they "believed that there are persons whose

**Table 1** Characteristics of study participants stratified by type of questionnaire

	Short questionnaire		Long questionnaire	
	N	%	N	%
Responders	456		435	
Gender				
Male	296	64.9	279	64.1
Female	160	35.1	156	35.9
Age				
Up to 44	66	14.6	75	17.4
45–54	179	39.6	160	37.0
55–64	178	39.4	156	36.1
Above 64	29	6.4	41	9.5
Missing	4		3	
Medical specialist	414	90.8	396	91.0
Additional education in alternative medicine	200	43.9	183	42.1
Site of surgery				
Urban	187	41.1	154	35.6
Rural	178	39.1	193	44.6
Suburban	90	19.8	86	19.9
Missing	1		2	
Response rates				
Total	456 of 928	49.1	435 of 1,867	23.3
North	72 of 154	46.8	87 of 308	28.2
East	102 of 196	52.0	81 of 393	20.6
West	140 of 289	48.4	126 of 580	21.7
South	140 of 289	48.4	140 of 586	23.9
Missing	2		1	

health complaints are caused by EMF". 28.7% did not believe so, and 16.6% said that they did not know (cf. Table 2).

In the long questionnaire, 33.8% of the GPs claimed to have read some information about health effects of EMF in the last 12 months (result not shown in the tables).

In the logistic regression analysis, three factors turned out to be associated statistically significantly with the perception of EMF risks (cf. Table 3). Physicians with an additional education in alternative medicine were significantly more often convinced of this association. GPs having confidence in the WHO were significantly less likely to see an association between EMF and health complaints. Region also was a significant predictor in the model, and GPs in the Western and Southern parts of Germany were more likely to believe in health impacts of EMF. Two more relationships were observed but were not statistically significant: GPs who considered their knowledge of EMF and health as good were less inclined to claim health impacts of EMF. Participants who were strongly

**Table 2** Perception of risks concerning electromagnetic fields assessed in the short and in the long questionnaire

	Short questionnaire		Long questionnaire	
	<i>N</i>	%	<i>N</i>	%
Responders	456		435	
Answers to the item “Are there persons whose health complaints are caused by electromagnetic fields when legal limit values are met?”				
Yes	170	37.3	250	57.5
No	278	61.0	149	34.3
Missing	8	1.8	36	8.3
Answers to the item “Do you believe that there are persons whose health complaints are caused by electromagnetic fields?”				
Yes			236	54.3
No			125	28.7
Don't know			72	16.6
Missing			2	0.5
Late responder analysis (proportion of agreements to the item “Are there persons whose health complaints are caused by electromagnetic fields when legal limit values are met?”)				
Early responders ( <i>n</i> = 177)	74	41.8		
Intermediate responders ( <i>n</i> = 137)	51	37.2		
Late responders ( <i>n</i> = 142)	45	31.7		

concerned about health risks in general (EMF risks not included) were more likely to associate EMF with health complaints.

## Discussion

Using the item “Are there persons whose health complaints are caused by EMF when legal limits are met” led to an estimate of prevalence of 37.3% with the short questionnaire, whereas the prevalence was estimated at 57.5% when the same item was used in the long questionnaire. The first value is the more valid one because the second is obviously distorted by selection bias. As is well known in the literature (Edwards et al. 2002) response rates in postal surveys decrease when questionnaires get longer. Barriers to fill in and return a questionnaire are larger in the case of long questionnaires. Long questionnaires are more often filled in by people showing special interest in the topic of the survey. As for our survey, we assume that the long questionnaire was preferentially filled in by physicians who were more concerned about health effects of EMF and thus had more interest in the topic. These physicians tended to associate EMF with health complaints more often.

In the Swiss study (Huss and Rööslı 2006), the other item was used (“Do you believe that there are people whose health complaints are caused by electromagnetic fields?”), and the authors found an estimate of prevalence of 61.4%. This is a much higher estimate than the one we found using the short questionnaire. The two items (in the Swiss study and in the short questionnaire of our study) are not identical, but in our long

questionnaire (where both versions were included), these two items led to similar estimates of prevalence, and from this, it can be seen that they are not too different in their meanings to GPs. We suppose that there are two explanations for the different estimates of prevalence in the Swiss and in our study (short version). First, the difference is at least partly due to selection bias in surveys with long questionnaires (with our short questionnaire we obtained a response rate of 49.1% compared to 28.2% reported for the Swiss survey (Huss and Rööslı 2006)). Second, the difference might be due to regional differences. From our data, an east–west as well as a north–south gradient can be seen, and it is conceivable that the south–north gradient also extends to Switzerland.

For Austria, Leitgeb et al. (2005) found that 95% of GPs did not totally exclude that electromagnetic pollution could cause illness. The result of the Austrian study is not directly comparable with the result of the present study as different items had been used. From their results, Leitgeb et al. (2005) drew the conclusion that there was a considerable discrepancy between physicians' risk perception and present scientific knowledge concerning EMF health effects. Although measured EMF are far below the limit values recommended by the ICNIRP (International Commission on Non-Ionising Radiation Protection) a majority of Austrian GPs believed in health impacts of EMF. In our study, the proportion of GPs associating EMF and health complaints was lower than in Switzerland and Austria. Nevertheless, a considerable proportion of German GPs attributed health impacts to EMF so that the critical comment of Leitgeb et al. (2005) can at least partly be transferred to German GPs.

**Table 3** Logistic regression analysis to predict the perception of risks concerning electromagnetic fields

	<i>n</i>	Odd ratio	95% CI <sup>a</sup>	<i>P</i> <sup>b</sup>
Total	406			
Gender				0.58
Female	140	1.15	0.71–1.86	
Male (ref)	266	1		
Age				0.15
45–54	146	1.41	0.76–2.60	
55–64	149	1.10	0.59–2.03	
Above 64	39	0.58	0.24–1.36	
Under 45 (ref)	72	1		
Additional education in alternative medicine				0.00**
Yes	172	2.26	1.45–3.52	
No (ref)	234	1		
Confidence in the WHO				0.02*
High	171	0.60	0.39–0.92	
Low (ref)	235	1		
Subjective level of knowledge about EMF and health				0.16
Good	130	0.72	0.45–1.14	
Bad (ref)	276	1		
General concern about health risks				0.07
High	133	1.57	0.94–2.65	
Intermediate	129	0.86	0.52–1.43	
Low (ref)	144	1		
Region				0.05*
East	73	0.82	0.41–1.64	
West	120	1.74	0.95–3.19	
South	131	1.67	0.92–3.03	
North (ref)	82	1		
Site of surgery				0.15
Rural	184	1.09	0.67–1.79	
Suburban	80	0.63	0.35–1.15	
Urban (ref)	142	1		
Nagelkerke's <i>R</i> <sup>2</sup>				0.14

Dependent variable: Answers to the item “Do you believe that there are persons whose health complaints are caused by electromagnetic fields?” in the long questionnaire. Category of reference: “don't know” and “no” combined

<sup>a</sup> 95% CI 95% confidence interval

<sup>b</sup> *p* values refer to likelihood-ratio tests comparing the full model with the model omitting the respective variable

\* *p* < 0.05; \*\* *p* < 0.001

Still, it would be unrealistic to expect doctors to adopt established scientific knowledge completely. As mentioned in the results section, only one-third of German GPs said that they had sought information about EMF and health at least once in previous 12 months. Moreover, risk analyses in other fields gave some evidence that physicians took an intermediate position between experts and lay people rather than belonging to the group of scientific experts of risk assessment. So, Purvis-Roberts et al. (2007) dealt with the perception of risks from nuclear testing and found that

doctors were more risk averse than scientists but less risk averse than lay people. In another study, chemical risks were judged by different experts, and even among chemists, toxicologists and pharmacists, risk perception differed widely depending on education and vocational careers (Kraus et al. 1992).

An additional education in alternative medicine was one of the three significant predictors of belief in an association between EMF and health. This is consistent with findings in the Swiss study (Huss and Rösli 2006).

The second significant predictor in this study was the degree of confidence in the WHO. Physicians with confidence in the WHO were less inclined to see a relationship between EMF and health complaints. It is understandable that physicians who had more confidence in official organizations were less inclined to doubt established scientific knowledge. These results give the idea that GPs who are somewhat critical towards the natural scientific health research are more likely to assume health impacts of EMF. Particularly in the southern parts of Germany, GPs were more likely to believe in health impacts of EMF. It should be mentioned that in Germany, most protests against the erection of mobile phone masts are observed in the states of Bavaria and Baden-Württemberg. One might expect that doctors in the Southern parts of the country attributed health complaints to EMF more often, and this was observed.

Assessing the prevalence of GPs who attribute health complaints to EMF is liable to a selection bias because doctors assuming such an association are more willing to fill in questionnaires on that topic. Using a short, in addition to a long, questionnaire we managed to reduce the selection bias. Nevertheless, in the survey with the short questionnaire some selection bias might have remained. Therefore, a late responder analysis was done which was based on the assumption that the trend observed between the response time and the proportion of GPs believing in EMF could be extrapolated to non-responders. So, a further correction for the selection bias was possible although this method is somewhat speculative.

In the case of the health complaints most often reported in the study (like sleep disturbances, headache, tiredness) there is a little scientific evidence that they are caused by EMF (Berg-Beckhoff et al. 2009; Seitz et al. 2005). So, in conclusion, our results furnish proof that in Germany a considerable proportion of GPs attribute health complaints to EMF even in cases where there is little scientific evidence. Therefore, ways are to be found to inform doctors about established knowledge in the field of health impacts of EMF. As a majority of the participants in our study did not read any information about this topic in the 12 months preceding the survey there is need for well adapted and easily available information bringing GPs to the present state of scientific knowledge.

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